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Results from directly driven implosions of deuterated plastic shells filled with tritium gas

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56th Annual Meeting of the APS Division of Plasma Physics
New Orleans, LA, 26-31 October 2014

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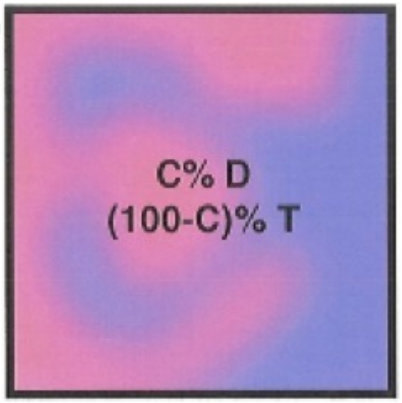
Outline

- Physics Motivation
- Experimental Design & Data
- Summary

A simple sub-grid burn model in the EAP code suite has been implemented…

Simple burn is calculated using

$$\Phi_{n,i} = \langle n_D n_T \rangle \langle \sigma v \rangle V_{cell} \Delta t_i$$



Defining: $n_D = c \cdot n_{ion}$ And letting: $c \equiv \overline{c} + \tilde{c}$

$n_T = (1-c) n_{ion}$

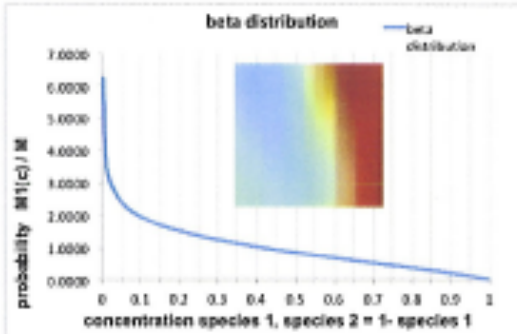
The above burn equation is modified to: $\Phi_{n,i} = \theta \langle n_D \rangle \langle n_T \rangle \langle \sigma v \rangle V \Delta t_i$

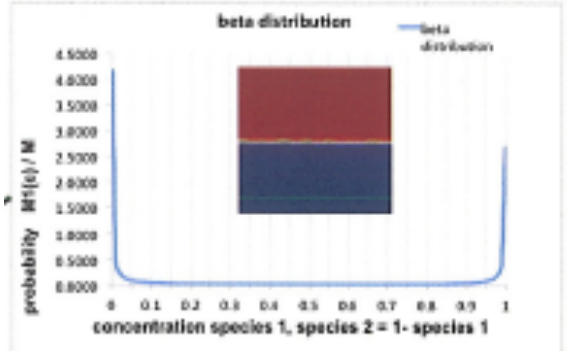
Where: $\theta = \left[1 - \frac{\langle \tilde{c}^2 \rangle}{\overline{c}(1-\overline{c})} \right]$ BHR may then be used to calculate $\overline{c}$ and $\tilde{c}$

But a PDF based burn model is the goal

$$p(c;\alpha,\beta) \sim c^{1-\alpha}(1-c)^{1-\beta}$$

Useful for describing uni- and bi-modal concentration distributions





BHR provides $\overline{c}$ and $\tilde{c}$ which are used to invert for α and β

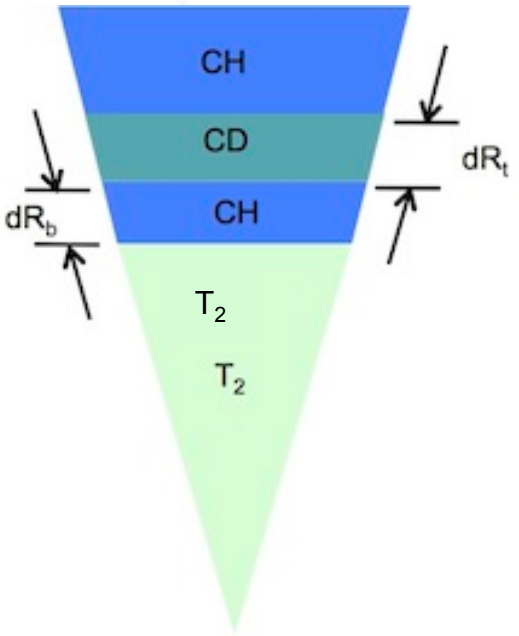
The PDF averaged burn is then calculated by:

$$\Phi_{n,i} = M\left(\frac{N_A^2}{A_D A_T}\right)\langle\sigma v\rangle V_{cell}\Delta t_i \int_0^1 dc\rho^2(c)p(c)c(1-c)$$

The MIXCAP platform was chosen to provide validation data, using both NIF and Omega

Omega version of the experiment

Count	dRt (µm)	dRb (µm)
4	1	0
4	1	1
4	1	2
6	0	0

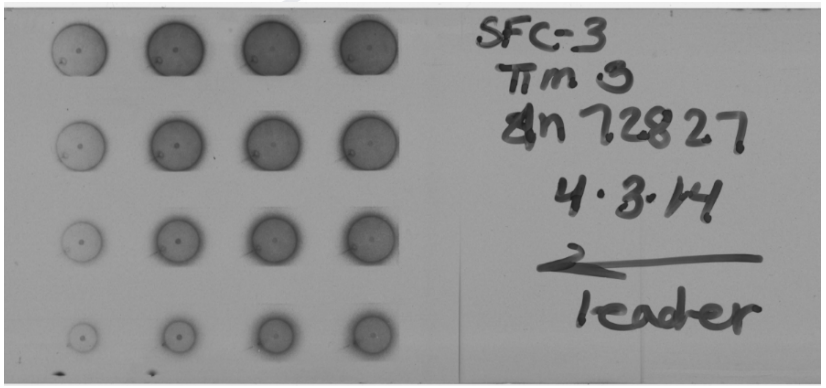


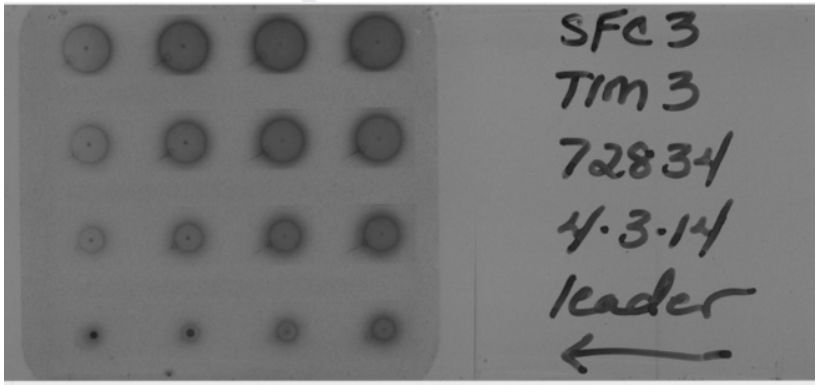
- 60 beams, SG4 phase plates
- SG10v001, 1 ns square pulse
- 27 KJ
- Capsules filled at LLNL with 4 & 10 atm of T_2, mounted at LLE.

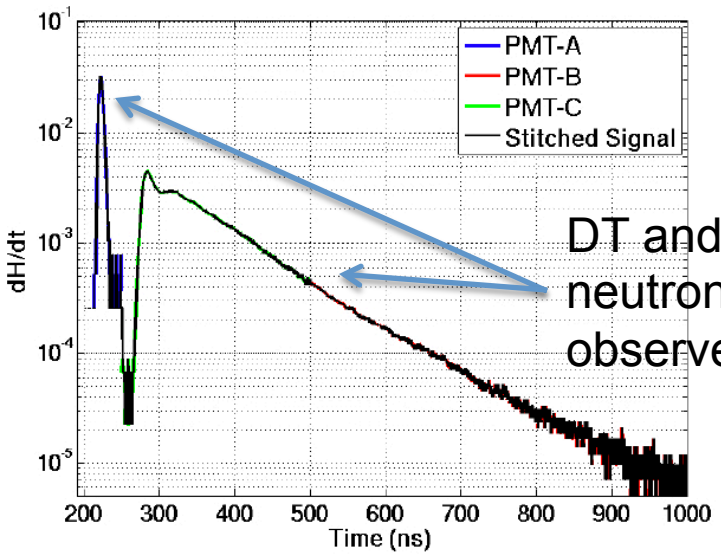
Required burn as the signature for mix

- **Burn Data**
  - TT and DT Yield (nToF)
  - Ion temperature (nToF)
  - Burn history (NTD GRH)
  - Core size (KB μ-scopes)
- **Hydro performance**
  - Radius vs time (SFC)

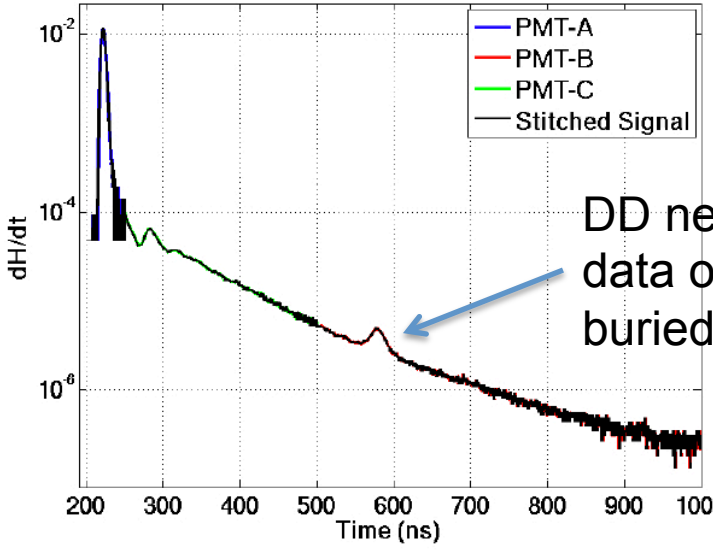
Excellent hydro and nuclear data was returned…







DT and TT neutrons observed



DD neutron data on 0 μm buried layer

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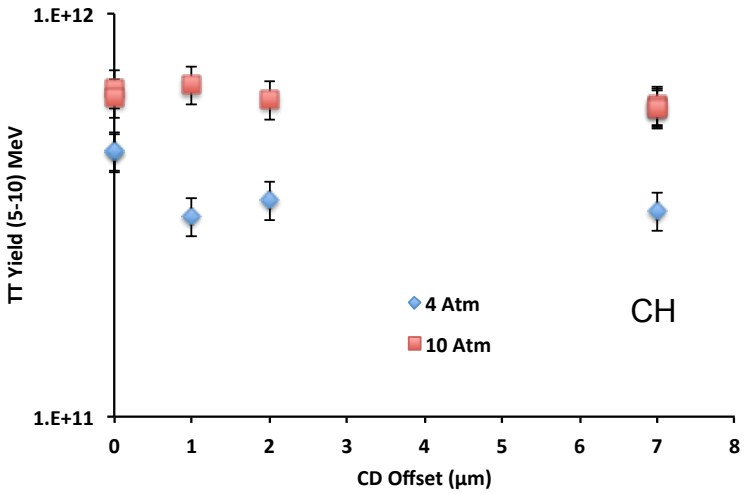
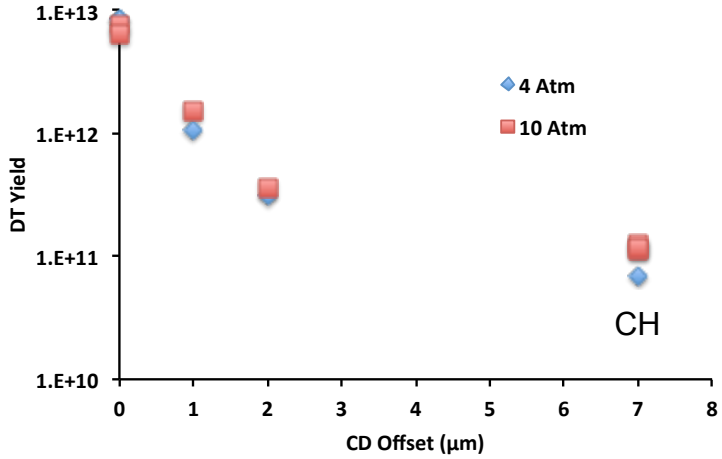
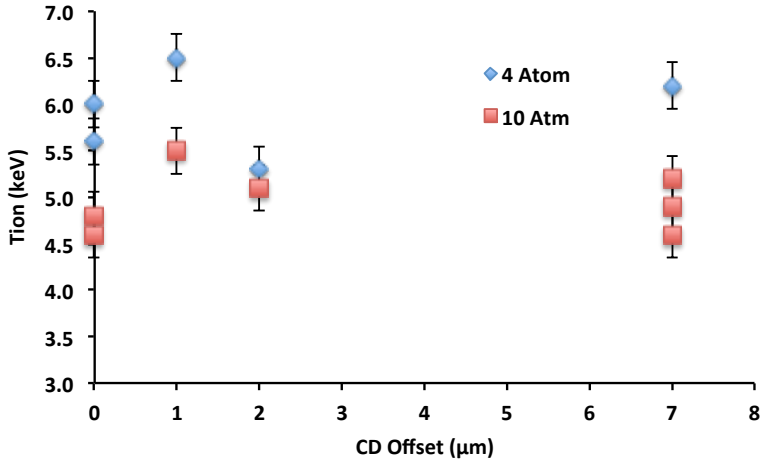
Yield data behaved sensibly…





- TT neutron yields varied by ~6% across shots from each fill pressure, ➔ core T_{ion} varied by ~2%.
- DT neutron yields with CD depth as to be expected.

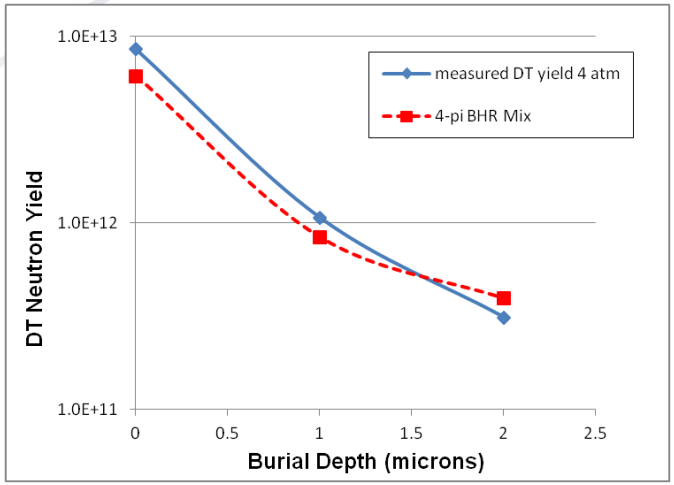
As did T_{ion}…

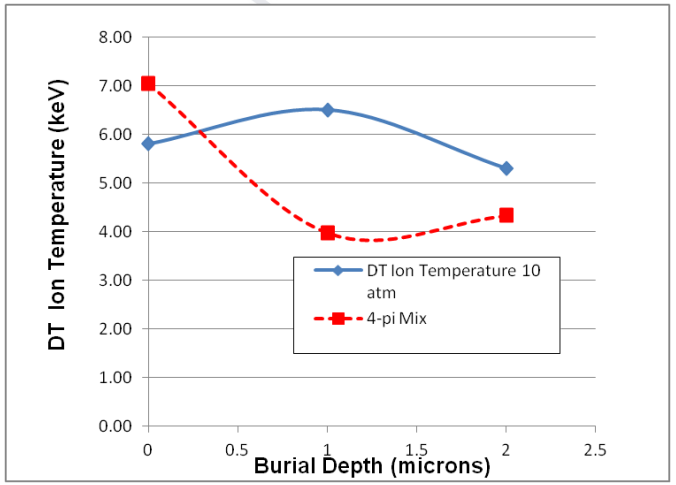


- T_{ion} varies by ~7% with burial depth
  - consistent with the core temperature ➔Yield variation due to concentration change

EAP simulation of 4 atm. fill with simple sub-grid burn is hit and miss…

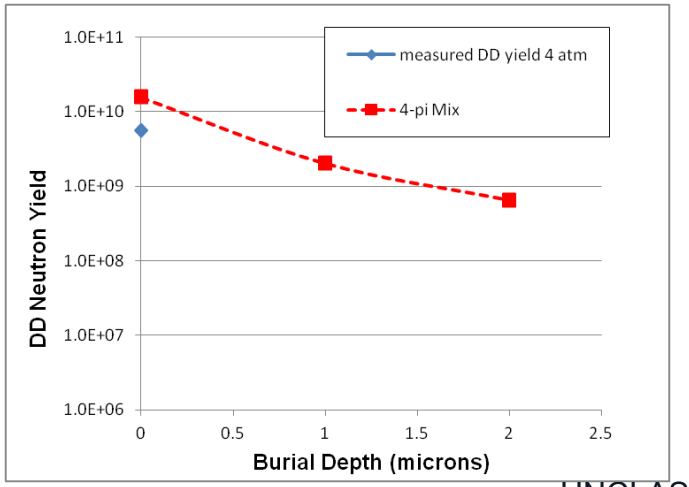
DT Yield

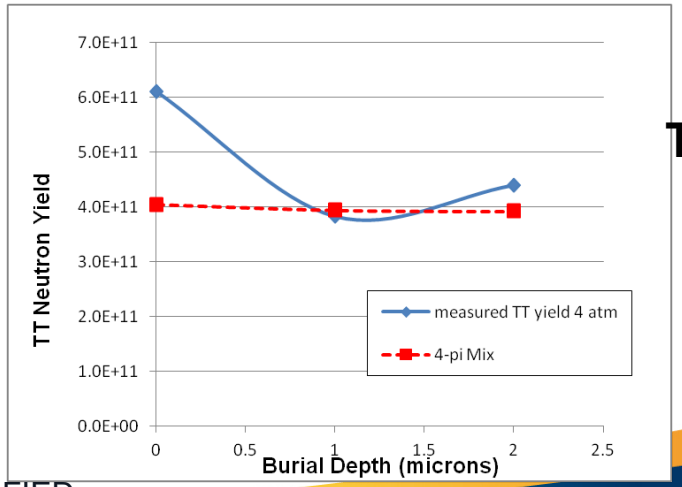




DT T_{ion}

DD Yield





TT Yield

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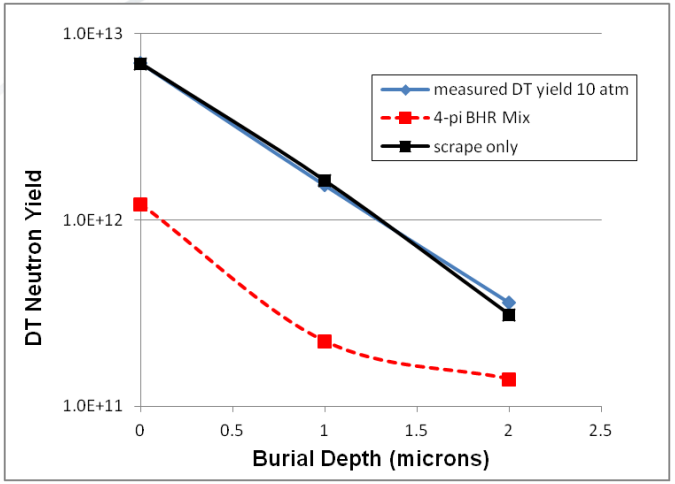
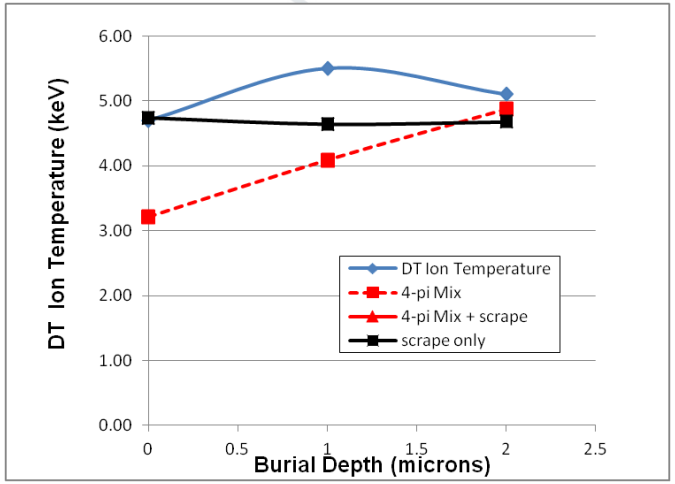
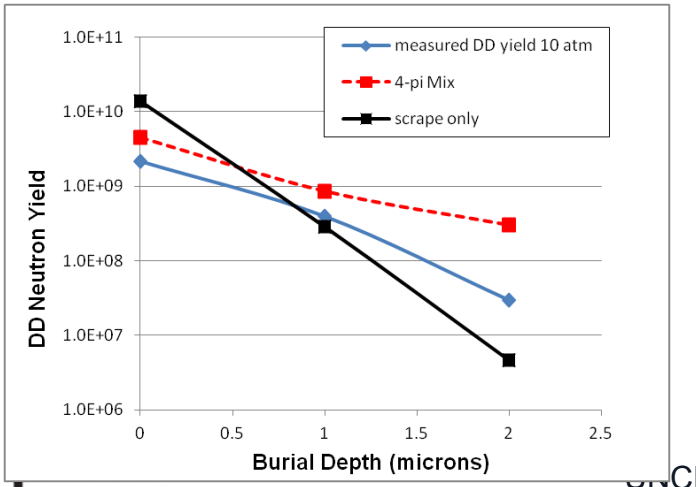
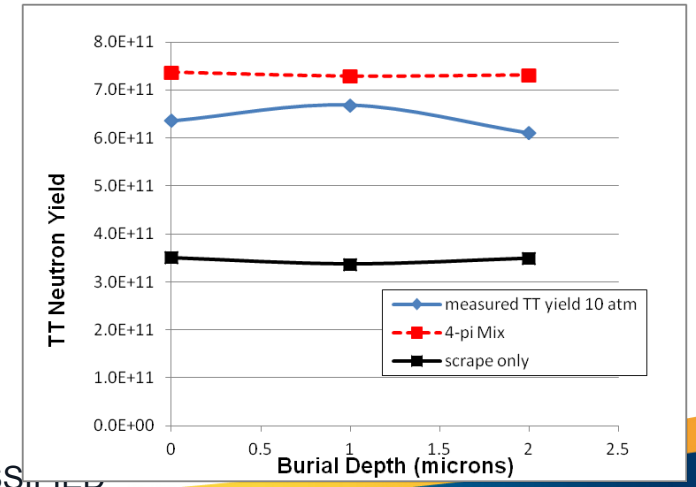
While 10 atm. Implosions are mostly miss, requiring ad-hoc pre-mix to match DT yields…









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Summary

- **High quality hydro and nuclear data were collected using Omega MIXCAP platform, including**
  - **TT, DT, and DD yields, DT T_{ion} and reaction history**
- **1-D capsule simulations using the EAP suite, BHR turbulence model, and a simple sub-grid burn have been performed.**
- **Comparisons with the results from the simple burn model do not compare favorably with data.**
- **Issues to address going forward include:**
  - **Laser imprint is ignored,**
  - **Surface roughness and defects.**
  - **Gradient scale length inconsistencies with BHR and an Eulerian simulation, consider switching to an ALE code base.**